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SOIL SURVEY
OF
HENDRICKS COUNTY, INDIANA

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DESCRIPTION OF THE AREA.

Hendricks County is situated in the central part of Indiana. It is bounded on the north by Boone, on the east by Marion, on the south by Morgan, and on the west by Putnam and Montgomery counties. It embraces about 420 square miles.

The area as a whole is a somewhat uneven plain with a general inclination toward the south. The elevation above sea level ranges from 800 to 900 feet for most of the region, with a few points rising to about 1,000 feet. Throughout the northeastern part of the county and in the west central portion the characteristic topography, except in the immediate vicinity of the creeks, is a succession of slight swells and low, broad divides usually without very definite trend and more or less uneven with regard to relative elevation. The depressions vary from mere swales a few rods across, to very irregularly extended flats involving several hundred acres. A few of the largest areas are several miles in length and expand in places to more than a mile in width, but in the northern part of the county such large bodies of low land are exceptional. Instead there are more frequent, although slight variations in relative elevation, but these differences are accentuated by the light gray shades of the higher ground in their strong contrast with the black color of the soils in the depressions.

In the southern part of the county the relief is much more pronounced. The National Road between Plainfield and Stilesville crosses several high divides that decline in long undulatory slopes to the wide valleys of Mill and Mud creeks. To the south of this highway the country generally slopes to the south and the local differences in elevation are generally greater than further north along the Pennsylvania and Big Four Railways. Except in the immediate vicinity of the drainage lines there is very little land on which the heaviest farm machinery can not be used with ease. In many places the comparatively mild contours of the uplands prevail to the very crest of the bluffs overlooking the valleys of the White Lick creeks. Occasionally hilly land extends some dis-

tance back, or the tributaries are bordered by very short, steep slopes.

Between New Winchester and Coatesville much of the surface has very slight relief, and there are frequent flats or slightly depressed areas, but these seldom include more than 10 or 20 acres. The largest body of level land in the county is that embraced by the several branches of Kamp's Run. This tract is somewhat lower than the uplands to the west and south and much inferior in elevation to the high morainic ridge to the northeast. The latter extends from below Danville nearly to North Salem, rising about 100 feet above most of the country to the east. The western slopes are very mild, but those on the eastern side are more pronounced. Near Danville the lower parts of the divide are cut by many short ravines, and hilly to broken land occurs in many places.

Throughout the northern part of the county there are numerous local elevations rising from 10 to 40 feet above the general level of the surrounding country. They vary from small mounds of less than one acre to ridges a fraction of a mile in length. From Danville southwest to the county line there also are many of these isolated elevations. Some of those along East Mill Creek are essentially gravel mounds with a veneer of loam, but those near Stilesville are broad ridges not entirely distinct from the other topographic features of that section.

The northern and northeastern part of the county which has such poor natural drainage is the southern extension of that great area of central Indiana, which is characterized by similarly immature development of its minor drainage systems. In this county artificial mains and the installation of hundreds of miles of tile drains has remedied the natural deficiencies so far as agricultural interests are concerned.

In the southern half of the county the drainage is much better developed. This is due in the main to the greater differences in elevation compared with the surface of the northern townships, and to the longer periods the streams have been actively eroding their valleys. The White Lick creeks and Ader Branch have trough-shaped valleys from one-eighth to one-half mile in width. Their floors are comparatively flat while the sides in most instances are nearly vertical bluffs from 20 to 50 feet in height. The abrupt declivities are most striking features of the landscape along the above mentioned streams and also on the lower Eel River, where there are bluffs upwards of 100 feet in height. The

small tributaries of these creeks usually have U-shaped valleys along their lower courses while the upper parts have relatively wider strips of alluvium bounded by low banks. In most cases the extreme heads of all these drainage lines have their origin in the structural depression of the uplands where little or no erosion has yet been accomplished. This, of course, is most noticeable in those branches that rise in the northern part of the county, but is also true of the majority of the small drainage lines in other sections of the area.

Mud Creek Valley is a broad depression with poor natural drainage until the present channel had been artificially opened. Since this was done the moderately high gradient has resulted in the widening and deepening of the main channel so it affords a good outlet for the numerous laterals that have been constructed.

The Mill Creek valleys are comparatively wide but consist in large part of low terraces. The recent alluvium is limited to narrow strips seldom more than one-fourth mile in width. These valleys and that of Mud Creek have no such bluffs or abrupt slopes on either side as occur along the other streams. The long upland slopes merge so gradually into the lowlands that no definite boundary can be drawn between them.

The terraces on the White Lick creeks and lower Eel River are nearly level benches 20 to 50 feet above the bottom lands. Their outer margins are sharp, stony declivities but on the upland sides the transition to the latter both with respect to topography and character of soil is very gradual.

The larger creeks maintain their flow the entire year. Many of the smaller ones are perennial, being fed by tile drains and numerous artificial ditches. Along all the bluffs, particularly those facing the south, springs are of very common occurrence and the quality of the water excellent. Near New Winchester, Amo and Clayton there are a number of flowing wells. In the valleys and in most of the larger areas of Clyde soils potable water is usually found at less than 15 feet. On the uplands the depth of dug wells ranges from 20 to 50 feet, and the supply is generally sufficient for all farm purposes. In recent years many driven wells have been sunk from 90 to 150 feet and an apparently inexhaustible supply is thus obtained.

All of this area was originally covered with a heavy forest. Exception must be made of a few small tracts in the larger bodies of black lands in the north central townships. These so-called

"prairies" were really marshy lands not yet sufficiently free from water to admit of cottonwood, willow, elm, or other moisture enduring species to establish themselves. The timber now remaining consists mostly of scattering trees in pastures, along highways and the groves around farm buildings. It is probable that less than 10 per cent of the area has escaped the plow. Practically all is included on well improved farms, the untillable portions having been utilized for pasture to such an extent that very little undergrowth or young timber of any kind now remains.

The price of farm land has advanced very rapidly the last 10 years. The best improved lands now range in price from \$125 to \$150 per acre, even larger prices being readily obtained for small tracts near the electric lines or close to towns.

The total value of all farm lands (Census of 1910) was \$21,735,044; of buildings, \$3,852,155. This is an increase of about 100 per cent compared with the returns of 1900.

The average size of farms is about 91 acres. There are a few individual holdings of more than 500 acres, but large estates are not common. The majority of farms include from 80 to 160 acres, with a good many of 40 acres, and even smaller ones near the towns. About 30 per cent of these farms are operated by tenants. The rates of rent now obtaining vary considerably, but are generally being advanced. Some farms rent for one-half of all grain and hay produced, others two-fifths of the grain crop and cash payments for grass land. All cash rental for farms consisting chiefly of Clyde soils is about \$8 per acre; of land less desirable for corn \$6 to \$8 is the usual rental price.

The county is crossed from east to west by four steam roads and two electric lines. Danville, the county seat, is also connected with Indianapolis by an electric railway.

The public roads are good, and rural delivery of mails is made daily to almost every farmhouse.

The average rainfall for each of the spring and summer months is sufficient to cause good yields of grain and grass, but the precipitation for the corresponding month in those seasons when there was a marked deficiency, is too low to meet the requirements of most crops. There are comparatively few years in which at some period of the growing season there is not a shortage of rainfall, and consequent decrease in yields of one or more crops. For this reason the necessity of conserving moisture, and the means of so doing is discussed at some length in the type descriptions. In

this respect, however, conditions in this area do not differ materially from those of adjacent counties.

The average date of the last killing frost in the spring is April 16, of the first in the autumn, October 19. The earliest in recent years was September 21, and the latest, May 21.

AGRICULTURE.

The government survey of the lands in this county was made in 1819, and the first group of settlers located on lower White Lick Creek in 1820. Owing to the better natural drainage of the lands in the southern part, and to the completion of the National Road in 1830, through this section, its development was much more rapid than that of the northern part of the area. As late as 1830, it is stated there were not more than fifty persons within the present limits of Union, Middle, Brown and Lincoln townships. The drainage of the larger areas of Clyde soils in these townships was not generally effective until about 1880, and at a little later date the flat lands on Mud Creek and lower Mill Creek were reclaimed. These drainage systems have been extended until practically all the lands are tillable.

Corn, wheat, oats, clover and timothy are the principal crops, and no other products have ever received any considerable attention. The general trend of agriculture is indicated by the following table taken from the U. S. Census returns:

U. S. CENSUS.

(Acreage and Yields of Principal Crops for Census Years 1880-1890-1900 and 1910.)

	CORN.		WHEAT.		OATS.		CLOVER.	
	Acreage.	Yield.	Acreage.	Yield.	Acreage.	Yield.	Acreage.	Yield.
1880.....	54,114	2,016,351 Av. 37.+	31,523	553,506 Av. 18	4,699	138,917	703 -
1890.....	50,637	1,642,054 Av. 32.+	32,956	376,831 Av. 11	10,178	259,872 Av. 25+	5,676 tons
1900.....	63,282	2,770,000 Av. 44.+	44,115	507,180 Av. 12	3,499	105,160 Av. 30+	14,981	20,519 tons
1910.....	76,085	3,125,343 Av. 41.+	26,614	363,548 Av. 14	17,522	467,480 Av. 25	2,935	3,452 tons

	ALFALFA.		TOMATOES.	
	Acreage.	Yield.	Acreage.	Yield.
1910.....	119	276 tons.	193	1,033 tons.
1911.....			596	3,114 tons.

Few farmers consider wheat in itself a profitable crop, and while the average returns from oats are somewhat better, neither of these grains would be grown as extensively as at present were it not for the opportunity thus afforded of seeding ground to clover and timothy. On all types except the Genesee and the darkest colored phases of the Clyde soils a frequent change to clover is recognized as indispensable in the maintenance of fertility, or from the more common view point, as essential to the profitable production of corn. The increasing demand for this grain is stimulating interest in every means that promises greater yields, especially on the light colored soils. The crop rotation practiced is planned chiefly with regard to requirements of corn although commercial fertilizers are used on both this crop and wheat. The consumption of manufactured fertilizers is increasing very rapidly in recent years.

NOTE.—Expenditures for fertilizers, from U. S. Census—

1879	\$1,217
1889	680
1900	14,710
1910	21,160

The grades of goods most commonly used have about the following proportions of the three essential elements: Nitrogen 1 to 2%; potash 4 to 8%, usually the lower figure rather than the higher; while nearly all carry from 8 to 10 of phosphoric acid. In most instances from 100 to 200 pounds per acre are applied, and a material increase in yield of corn and wheat are reported. It is also stated that the quality of the latter is generally improved. On the so-called "chaffy" lands, potash is being very generally used when such ground is planted to corn, and this substance invariably improves both the yield and quality of grain.

The demand for more or less specific information relative to commercial fertilizers increases as their use becomes more common. In a report of this kind it is quite out of the question to go into detail regarding commercial fertilizers. As yet no extensive or continued field experiments have been made on the more important types and in the absence of such experimental work no very specific directions can be made regarding the most profitable combinations of the several elements for each crop. Some of the principal underlying fertilizer practice and the application to local conditions may be outlined.

The Clyde soils are so well supplied with humus that in average seasons and under fair conditions of tillage the available nitrogen seems ample for corn and wheat. The addition of further supplies as in a complete fertilizer which may contain from 1 to 2% is not necessary or at least is doubtless unprofitable. Changes to clover, especially on the lighter phases or those so long in cultivation that the color is preceptibly lighter than the normal and there is a tendency to clod, is beneficial chiefly in improvement of the physical conditions. It is also true that the incorporation of brown humus, or that which results from decay of green vegetation or manure greatly improves the light brown phases of this type with regard to requirements of most crops.

The Miami soils are so generally deficient in humus that the available nitrogen supply is low. The physical condition of the silt loam, especially of the heavier phases, is often unfavorable to the development of nitrates in the soil or to the release of mineral elements in the subsoil. The application of a complete fertilizer temporarily remedies this deficiency, so to speak, and enables a crop to start off promptly and make an early growth that may be of greater advantage throughout the remainder of the season. With corn the same result would be secured by drainage, tillage and addition of rather liberal amounts of manure or of some legume plowed under. There would be not only a direct and immediate increase of plant food, but the ability of the soil to endure extremes of wet or dry weather, would be immeasurably improved.

With regard to wheat an increase of nitrogen and improvement of physical conditions may not so nearly meet requirements as in the case of corn. The very general increase in yield and improvement in quality following applications of fertilizers evidently indicates some particular need of this crop not fully met by the Miami soils even under most favorable conditions of season and tillage.

In general no method of increasing the nitrogen supply is superior to, or even equals, the methodic rotation of crops in which clover or some legume has an important place. On most farms, the manure supply is limited and no very marked increase in the future seems probable.

As indicated in Chapter IV, the origin and mineralogical composition of the soil forming materials leaves little or no doubt as to their comparative richness in potash. The potash supply of all except possibly the limited areas of mucky soils and very light

sandy types is practically inexhaustible. So far as this problem concerns the farmer it is a question of rendering this element available through drainage, tillage and presence of organic matter in the soil.

With regard to phosphorous, the above observations do not apply quite so well because this element does not exist in loessial or glacial soils in such amounts as does the potash. But the total amount as measured by crop requirements is adequate for many years of tillage, and no "deficiency" or "exhaustion" exists as is assumed by many farmers. This is plainly shown by chemical examination of the dominant soil type of this region and is also supported by field observations. On the light colored soils the limit to crop yields is usually some physical factor, as unfavorable seasons or poor condition of the soil, but in a larger way it seems to be determined chiefly by nitrogen supply. Where this element is restored by clover growing the yields of corn, clover and timothy are comparable with those on the black soils. In both cases, and all these soils are closely related with regard to character of mineral constituents, there is little indication of crops being cut short by lack of fertility. As previously stated the limit is most frequently determined by the water supply or some other physical condition of soil, that precludes as heavy a growth or as full a development of the plants as would otherwise be possible.

Since most of the brands of fertilizer used in recent years are high in phosphorous and this application in moderate amounts usually gave increased yields of corn and wheat it seems that this element may be profitably supplied in some form. In the complete fertilizer it is the acidulated form that is obtained. In a few instances "floats," or finely ground phosphate rock has been applied to the Miami soils but sufficient time has not yet elapsed for results to be apparent. In this form phosphorous became available slowly, or during a term or years succeeding its application.

In general the most practical crop rotation for this section consists of corn, followed by wheat or oats, and the ground seeded to clover to remain two years. The clover ought to keep up the nitrogen supply, and it will do so if a sufficient proportion of the two years' growth is returned to the soil. On the light colored soils one crop ought to be turned under, and considering the profit a good crop of corn assures there is little doubt of the practicability of so utilizing a part of the clover growth. The present

practice usually results in most of the crop above ground being removed from the land.

Since the presence of organic matter renders more of the mineral elements of fertility available than occurs under otherwise similar conditions an increase of the humus supply is practically an increase in all the essential mineral constituents. This fact should be kept in mind in comparing crop returns on the Miami and Clyde soils, for the abundance of organic remains in the latter is the chief difference between the two types.

The lime requirements of the soils have been discussed in the type description.

The keeping of live stock has such a direct bearing upon the maintenance of fertility that the number of farm animals in this county may be of interest.

According to Indiana Department of Statistics the number for 1912 is as follows:

Horses and colts, 8,635; mules, 1,412; cattle, all kinds, 14,197; hogs, 40,407; sheep, 11,745.

With regard to production of manure ten hogs or sheep are counted as the equivalent of one horse or cow, this means that it is about one animal to seven acres of improved farm land. Even if all manure produced were returned to the land without loss, the amount would not be much in excess of one ton per acre per year. The method of handling on many farms is very wasteful. In the villages the accumulation at livery barns is usually donated or sold at a nominal price to any one who will haul this away.

Dairying has become a very important industry in the county since the shipment of milk to Indianapolis is facilitated by the several electric lines crossing the county. Compared with other Indiana counties this one ranks high in the number of cattle annually fattened. Eel River Township enjoys the distinction of producing more fat cattle than any other township in the State.

Bluegrass and white clover form practically all the grass in the permanent pastures. Most of the land devoted to this purpose is the Miami loam, but the silt loam also forms much of the woodland pasture and very frequently it is the heavy phase, the soil being notably acid and markedly deficient in lime. An application of several tons of ground limestone would immeasurably benefit such pastures, for both the blue grass and clover are lime loving plants and thrive best when this mineral is abundant. But not much attention is given the pastures either in the way of fertiliza-

tion or mowing of weeds. The small ragweed infests much of the upland pastures and meadows and some of the bottom lands are hardly less free in the fall from various rank growing species.

In the last few years alfalfa growing has commanded considerable interest and small fields, experimental in many instances, are quite numerous. As a rather general estimate of relative adaptability of several types as indicated by these fields the Miami loam ranks first, the Clyde soils second, and the Miami silt loam third. The heaviest yield observed was an a well drained Clyde silty clay loam. Ideal conditions are found in those phases where lime nodules occur in the subsoil and the water table is within 6 to 8 feet of the surface. Good stands have been established on the best drained Genesee types. On the Miami loam a calcareous substratum is usually found at less depth than under either of the other upland types and this is a factor of much significance in alfalfa culture.

Any soil type well adapted to corn should be suitable for alfalfa with additional requirements of lime and inoculation. Since sweet clover has so generally spread along the road and railway line, the soil in places requires no artificial introduction of the necessary bacteria, but it is well to scatter dirt from sweet clover patches over the ground at about the time the seed is sown. Lime at the rate of from 4 to 6 tons per acre is necessary in most instances and an absolute requirement on the Miami silt loam which is invariably acid. July and August seeding seems to be safer than spring sowing. The land should be plowed early and frequently disked to destroy all weeds.

Not much attention has been given to trucking of any kind except production of tomatoes for canning purposes. The acreage varies much from year to year and the annual returns are also extremely variable. The price in recent years has been about \$9 per ton with yield of from less than 1 ton to about 10 tons per acre, the latter being a normal production. The Miami silt loam and loam are said to produce a firmer fruit than the Clyde soils.

Strawberries are grown, in a few instances, in patches of one or two acres, and the local demand readily takes all the production. It would seem that this industry could be made very profitable near one of the electric lines which afford almost hourly service to the city of Indianapolis.

There is no doubt of the adaptability of this section to produce

apples on a commercial scale. The Miami loam in particular affords excellent sites for orchards and all except possibly the heaviest phase of the Miami silt loam may be considered well suited to this fruit. The present orchards, in many instances, consists of old trees that have not received much attention in any way whatever. With such care as pruning, spraying and cultivation as is given in fruit producing sections commercial orchards here would be equally profitable. There is little present demand for summer and fall varieties but this is partially due to lack of sufficient quantity by any one grower to assure commission men of a dependable supply. The winter varieties are the Ben Davis, Genet, Jonathan and other equally desirable kinds. The quality, through failure to spray, is usually very inferior.

SOILS.

Throughout the county the prevailing surface material is a silt or silty clay, having an average depth of about 3 feet. In the extreme western and northwestern parts of the area it is somewhat deeper while in the southern portion the thickness of the silty deposit is generally less than 2 feet.

This superficial stratum overlies glacial material known geologically as early Wisconsin drift. This till, at least in the southern part of the county, rests upon the Knobstone shales, which are exposed in a number of places along White Lick Creek. In but few places on the uplands is the depth to rock less than 50 feet. As a rule it is greatly in excess of this estimate, so that neither the shales nor glacial material older than the Wisconsin has entered into the soils to any appreciable extent.

For a few feet below its contact with the overlying silty clay the till, especially on hillsides, is usually a reddish brown granular clay with more or less sand and stony material. The brown coloration is due to the higher degree of oxidation of the iron content in this upper portion compared with that below. The latter is a very light brown, or pale yellowish-brown mixture of silt and clay with enough sand to render it rather porous and friable. Weathered exposures are usually very crumbly, and in fresh excavations it may be very fine or compact, but the material never approaches an impervious condition. Its physical structure generally admits of relatively free circulation of air and water throughout the mass. This is also favored by the presence of much coarse material varying in size from gravel to small stones. Large

boulders are not of common occurrence in the drift. Most of this rock consists of well rounded fragments of quartz, close grained granites and other hard resistant species. Pieces of shales, sandstone and other weak rock seldom occur in any considerable numbers, but at a depth of 6 to 8 feet below the surface limestone fragments are relatively numerous and from this depth downward the till is so calcareous as to respond freely to hydrochloric acid.

In the valley of Mud Creek stratified sand and gravel are found a few feet below the surface and evidently extend to a great depth. Similar conditions prevail on Mill Creek above Stilesville, indicating in these places pre-glacial valleys, deeply filled with outwash material. In some of the flat areas of black lands in the northern part of the county water laid gravel occurs at a depth of a few feet, but such deposits are not so commonly found as in Boone County.

While the glacial material has entered to some extent into the composition of all the types the dominant ones owe their origin to the silty clay, or loess. This thin but almost unbroken deposit is found everywhere except in the creek valleys and in the larger depressions of the uplands where local erosion and redeposition have modified its original condition to a greater or less extent. On the steeper slopes it has also suffered partial removal or lost its identity by admixture with the underlying till. Elsewhere the contact between loess, for such it evidently is, and the boulder clay is well defined, and the two deposits have distinct physical characteristics.

To a depth of about a foot a representative section of loess consists chiefly of silt, or the grade of soil particles between clay and very fine sand. The latter is the next highest component, but there is not usually enough coarser sand to materially effect the physical properties. The percentage of clay is usually too low to impart a marked degree of plasticity or render the material sticky when wet, or very hard if dry. In general this silt surface layer is characterized by extreme friability and a degree of porosity highly favorable to desirable moisture conditions and consequent ease of tilth.

Between the depths of 12 and 30 inches, although these limits are subject to more or less modification by topographic position, the loess has a higher content of clay. Its structure is more compact than that of the upper layer and internal drainage and aeration are less effective. This is indicated by the mottled coloration usually observable in this stratum. Beyond a doubt the retentive

nature of this silty clay would be more noticeable in its effect upon average moisture conditions, were it not for the relatively open glacial material immediately below. The latter tends to induce underdrainage and favor deeper and freer circulation of air than would be the case if the tight silt-clay had a greater depth. The average conditions in this respect are expressed by the normal phases of the Miami silt loam, which is the dominant upland type in this region.

Where the loess has a somewhat greater depth a phase of this type has been developed characterized by reluctant drainage and deficient aeration. It is indicated on the soil map as the heavy phase of the Miami silt loam. Extreme conditions of this kind are locally termed "clay spots," but may be found in all phases of the silt loam.

On the other hand where the loess is shallow and there has been more or less admixture of coarse material from the underlying till, relatively free underdrainage and aeration has resulted. Consequently there has been a more complete oxidation of the iron content and brown and yellow are the characteristic colors throughout the soil section. Such modifications of the silty material often have the texture of a loam, and areas where these conditions generally prevail have been mapped as Miami loam. Two quite distinct phases are recognizable. On developed or comparatively steep erosional slopes near drainage lines, while another occurs on the mound-like morainic elevations that are so conspicuous in some sections.

The surface soil of these types is generally very light colored. There is but little humus in any form and practically none of the black carbonaceous vegetal remains that characterizes the Clyde soils. All the Miami type was originally forested, and such a covering, on well drained soils, never results in such accumulations of organic matter in the surface soil as follows a long continued occupation by herbaceous vegetation or prairie grasses.

It is also probable that the light color of the surface soils, where no organic matter is present, indicates a degree of leaching, considerably greater than has occurred in the material at a little greater depth. This suggests a lower content of mineral elements of fertility in the surface soil. With respect to lime this is true, and doubtless is applicable in some measure to the other less soluble but equally important constituents. Under favorable physical conditions all of these types respond so well to tillage and addition of

organic matter as to indicate that the silty clay or loess, as a whole, is comparatively rich in mineral plant food.

In the depressions of the uplands conditions originally were favorable for the preservation of organic remains and in practically all such situations the Clyde soils were developed. While most of the black lands were heavily forested when the first settlers entered the county it is probable that most of the dark carbonaceous material that renders them so valuable agriculturally is a heritage from that comparatively recent period when all these tracts were marshy prairies. Most of the humus is vegetable matter in that form it assumes when decomposition takes place under water or when air is partially excluded. As an active element of fertility it is of inferior value to the brown humus which results from the decay of animal and plant remains in the first few inches of a well-drained soil.

The mineral constituents of the black soils consist chiefly of the silty clay either in practically its original position, as in the case of small local depressions, or of such material derived by surface wash from adjoining higher grounds. In the assorting process that thus resulted very fine silt and clay were generally first deposited in these shallow lakes and ponds and the final filling, largely accomplished by accumulation of plant remains. Thus the subsoils of the larger areas are usually stiff, silty clays inclined to be somewhat impervious. The condition in many instances is relieved by occurrence of gravel immediately beneath the clay, or more frequently of the relatively open till at a depth of a few feet below the present surface.

In some instances the proportion of organic matter on the surface is so high that a mucky or "chaffy" soil is found. Such conditions as well as the few limited areas of true muck are less common in this area than in the counties to the north. In a course of time all these will change to soils of normal structure.

The development of these types has been so largely a function of topography that a relief map would show the approximate location and extent of the individual areas of each type. On the uplands the Miami silt loam and Clyde silty clay loam are so closely associated that this actual representation by this means would require a map with about 1 foot contour interval. In this section very slight differences in elevation, if associated with obstructed drainage, have given rise to pronounced modifications in the organic matter content and in many instances to the texture of the soil and subsoil.

The alluvial lands consist of reworked material of local origin. In the White Lick drainage a silty or fine sandy loam is the prevailing surface soil while coarse sand enters largely into the composition of the lower subsoil. There has been a slight development of terraces along these streams but they are of such comparatively recent origin that the materials have not suffered much modification by weathering, differential drainage, or addition of organic matter.

The high terraces on the larger streams are distinct from those just mentioned. They are much older, certainly pre-loessial, for the silt-clay stratum forms the surface material in all places except where removed by recent erosion, as on the marginal slopes, and flanks of ravines.

On Mill Creek and its several branches a silt loam is the prevailing type, due perhaps to the wider valleys of that stream and to its lesser gradient compared with the White Lick creeks. The source of material of the former stream is chiefly the surface silt or loess, while the alluvium of the White Lick creeks contains much glacial debris on account of the deeper valleys the main streams and the principal tributaries have carved into the drift.

In all instances the alluvial soil of the larger streams is characterized by absence of organic matter and a consequent lighter color than prevails in a soil better supplied with humus. The color is a pronounced brown, suggestive of exceptionally uniform oxidation and distribution of the ferruginous matter. Owing to their structure and to the elevation above the stream channel the drainage throughout is generally good. This, in the absence of organic matter, favors the development of the uniformly brown color. The failure to accumulate humus may be ascribed to the same cause as that operative on the Miami type; that is, to the originally heavy forest cover in conjunction with the effective drainage.

MIAMI SILT LOAM.

The Miami silt loam is the light colored soil commonly called "clay land," or "white land" by farmers. It is the dominant type throughout the county, forming 70 per cent of the total area.

To a depth of 8 or 10 inches the soil is composed chiefly of silt and very fine sand. There is usually a little medium sand present and scattering pebbles and small stones are frequently found on the surface. Cultivated ground, if dry, has an ashy gray color, but under usual moisture conditions very light brownish gray is

the characteristic tint. The friable porous clods crush easily to a fine earth in which there is but a slight tendency to granulation, or the "crumb structure," observable in the black soils. This is due to the low content of organic matter. Even in virgin soils there is very little humus below 4 or 5 inches.

The subsurface soil is usually a gray or mottled gray and yellowish brown silt loam that at 10 to 15 inches changes to a stiff, compact silty clay loam. To a depth of 25 or 30 inches it offers considerable resistance to penetration by any implement and is not usually so permeable to air and moisture as is desirable. While somewhat crumbly on drying it has rather close structure with but slight development of granulation. This condition is modified in some measure by occurrence of coarse sand grains and occasional small pebbles. Where these form an appreciable proportion of the material brown and yellow tints prevail without much grayish mottling, but this latter coloration is characteristic of all the heavier phases of the subsoil.

Below 30 inches the proportion of sand and gravel rapidly increases, this stratum varying from a coarse loam to sandy clay. It is much more open and permeable than the silty clay overlying it. The available moisture content is usually much higher, often sufficient to render the material sticky or plastic when the surface soil is quite dry. The color is generally reddish or yellowish brown. Iron concretions are not commonly found in the lower subsoil but are more numerous in the surface and middle soil.

The Miami silt loam has this characteristic structure: a gray silt loam surface with mottled silty clay subsoil that at less than 40 inches changes to a sandy or gravelly material. The depth at which the latter occurs and the relative thickness of the soil and middle subsoil sections is somewhat variable, but not to such an extent as to materially modify the general physical properties of the type. These variations usually have a rather definite relationship to local topography. The soil and subsoil are of least thickness on slopes and deepest where the surface is nearly level or but gently inclined. On the latter the gravelly substratum may be at a greater depth than 40 inches, while on convex slopes of moderately high gradient it may be within 12 or 18 inches of the surface. In the latter case the soil is generally more sandy and has a brown color. Such phases are essentially the Miami loam and have been so mapped if large enough to show on the scale used. In depressions the soil has more than the average amount of humus, and if

the natural drainage was poor the type passes into the Clyde silty clay loam. There are innumerable gradations of this character not practicable to indicate on the map.

Certain regional variations in the average thickness of the silt-clay layer are recognizable. It is of greater depth in the western townships than in the central ones, and is considerably thinner in the southern part of the area than in the northern portion. South of Plainfield and Cartersburg most of the Miami silt loam has sandy or gravelly material at less than 25 inches. Heavy phases and "clay spots" are of rare occurrence in this section of the area.

All of this type was formerly covered with a mixed growth of deciduous trees. On the heavier phases beech, ash, hickory, white oak and elm were more common than on the lighter textured phases. On the latter, sugar maple, poplar, walnut and red oak formed a large proportion of the forest. There seems to have been less tendency on this type toward the dominance of certain species than on the Clyde soils.

With the exception of the limited acreage in woods pasture all this type is now cultivated. Large boulders are of rather common occurrence in some sections, but neither they nor small stones are numerous enough to interfere with cultivation.

The usual yields of corn on this type are below rather than above 40 bushels. Ground that has been sown to clover and fields in which there are numerous swales where the soil has more than the average amount of humus often produce 50 to 60 bushels. The latter estimates indicate the possibilities of the type instead of present actual returns. The deficiency in organic matter is chief cause of the comparative low average yields, but the close nature of the subsoil renders the type very susceptible to irregularities of rainfall, a factor of great importance in most seasons.

The yields of oats are more generally affected by seasonal extremes than if the soil were somewhat richer in organic matter. In 1912 when the precipitation was ample the average returns were about 50 bushels, but in 1913 dry weather prevailed during May and June, and much of the oat crop was hardly worth harvesting. Wheat sometimes yields 25 or 30 bushels, but the usual returns range from 10 to 20.

After a stand is secured, timothy and clover do well on even the heaviest phases of the type. The production of hay is less than on the Clyde soils, but the quality is good. Considering the fact that all the surface soil is markedly acid it is somewhat remarkable that clover does so well. The free lime in the substratum at

4 to 5 feet below the surface doubtless compensated for the deficiency in the soil and subsoil.

All of the Miami silt loam stands in need of more humus and better internal drainage. The first is so obvious as to hardly need mention, but the relationship between organic matter and the nitrogen supply as well as its effect upon availability of other elements of fertility are discussed in the chapter on agriculture.

Tile drains immeasurably improve the physical condition of the type. They should be laid in rather than below the heavy subsoil and the distance apart in the heavy phases should be not less than 6 or 8 rods, and closer would be advantageous in many instances. Tiles not only remove excess water but induce a freer circulation of air than usually takes place in such tight subsoils. This material is particularly in need of better aeration especially where mottling is conspicuous, or bluish gray clay is found in the lower subsoil. Under natural conditions much of the plant food in the subsoil is unavailable through frequent saturation and lack of oxidation.

Where drains have been installed farmers state that the cost is soon returned in increased yields of grain.

Lime is needed in the soil to correct the acidity. From 2 to 4 tons per acre would be beneficial in all cases but greater amounts would not be amiss. Liming and occasional crops of mammoth clover turned under with the drainage improvement outlined in the preceding paragraph, would render this type far less susceptible to wet and dry weather, and also reduce the apparent need of fertilizers. The latter requirements are taken up in the chapter on Agriculture.

The present price of farms consisting largely of this type ranges from \$125 to \$150 per acre. The rental value is usually one-half of grain raised or if cash is paid the price ranges from \$5 to \$7 per acre.

The mechanical analyses of representative samples of this type gave the following results:

Heavy Subsoil Phase.—Where the surface is nearly level and the silt-clay, or loess, has a depth of 30 or 40 inches a heavy phase of the Miami silt loam is usually found. The surface soil is generally very light colored if dry, and more sticky and inclined to puddle when wet than are the normal developments of this type. The deficiency in organic matter and lack of granular structure is very apparent in the soil.

The upper subsoil is generally characterized by much mottling

and the lower portion is more compact as to sometimes be designated by farmers as "hard pan." It is not impervious, however, although at about 40 inches a layer of tenacious, bluish gray clay is sometimes found which is even less permeable than the silty clay loam above it.

The most pronounced developments of this phase are the "clay spots" that occur in practically all the larger areas of Miami silt loam. Fortunately they are not very numerous and the average size is usually less than one acre.

In the extreme western part of the county where the loess has more the average thickness and the surface relief is slight a heavy phase is of common occurrence. The "clay spot" condition obtains chiefly on these local flats where both surface and underdrainage are decidedly poor. In many instances much of the adjacent upland is but little better in this respect, so that the heavy phase generally prevails. The areas so indicated are but approximate representations of this phase because no sharp line can be drawn between it and normal developments of the silt loam. A slight slope toward a drainage line or local elevation suffices in most instances to prevent the sluggish drainage which is the chief factor in the development of the "beech tree" land, as this is locally termed.

The suggestions concerning drainage of the Miami silt loam are particularly applicable to this phase.

Low Phase.—This phase of the Miami silt loam is represented by numerous low lying areas in Mud Creek Valley. Some of them are islands of gray soil in the large tracts of black land, on the lower course of this stream, Post oak flats, some of these were formerly termed on account of prevailing timber. The areas near its source are mostly depressed extensions of upland slopes having but slight elevation above the adjoining alluvial or semi-alluvial lands. While the distinction between this phase and the normal development of the type is chiefly topographic the drainage conditions thus induced have in most instances modified the soil materials and affected the agricultural value.

The soil is a silt loam, similar to that of the uplands, but it usually has very light color, and in many instances a peculiar lifeless, ashy gray appearance not suggestive of a high degree of fertility. There is marked absence of granulation and even where there is some medium sand present, as is often the case, the soil is more inclined to pack after rains, than most of the type on the

uplands. The organic matter content is low and the sharp contrast in this respect with the adjoining black lands is often marked.

The subsoil is a mottled gray and yellow silt loam or silty clay loam. The aeration and drainage are usually poor, or at least not effective to as great a depth as in the higher lying phases. The lower subsoil is generally a sandy material but instead of reddish grown tints some shade of light yellow or bluish gray is not uncommon. In some of the isolated areas in the Clyde loam the deep subsoil is a yellowish fine sandy loam.

Under natural conditions the average level of the ground water was pretty close to the surface of much of these low areas, but since the adjacent land has been drained it has fallen to a depth of several feet. The general condition is improving but the tight subsoil yields rather slowly to effects of better underdrainage. Otherwise the gray and pale yellow coloration would tend to a reddish brown.

Most areas of this phase are especially in need of more complete drainage systems. Wherever the surface soil has an ashy gray color a compact subsoil will be found and this should be opened up by tiles which will give better results than open ditches. With improved drainage it is highly probable that the soil would assume a better physical condition, but liberal applications of lime and incorporation of vegetable matter would insure most effective and permanent change in this respect and greatly increase the available fertility. Under natural conditions or where but little artificial drainage has been secured, the yields of grain are very dependent upon weather conditions during crop growth.

The general increase in the depth of the silty surface stratum that covers all the uplands of this region becomes quite apparent in the west tier of townships of Hendricks County. From New Winchester southward this condition finds expression in the heavy phase of the Miami silt loam. North of Eel River where the surface relief is much more pronounced than in the vicinity of New Winchester the silty upland soils resemble the Miami silt loam, which has an extensive development in the counties west of Hendricks. The areas in the county indicated as Miami silt loam are essentially a broad transition with many local variations according to topography between the true type and the Miami silt loam. It consists of the same kind of material and has about the same agricultural value as the latter. The chief difference is in the depth to boulder clay. This is seldom less than 35 or 40 inches—except

on comparatively steep hillsides—and sometimes is as much as 4 or 5 feet. Owing to the more pronounced surface inequalities compared with the topography of most of the Miami silt loam, and also to the evidently slight increase in sand, this deeper silt usually has a brownish color instead of gray and yellowish mottlings. This is not everywhere the case, but most of the areas mapped as Miami silt loam have as good aeration and as effective subdrainage as the normal phases of the Miami.

The surface soils of these types—as represented in this area—are practically identical. In each case similar conditions with respect to topographic position and drainage have given rise to like coloration, organic matter content and general agricultural values.

The subsoil of the Miami silt loam is usually a grayish or slightly mottled silt to a depth of 10 to 15 inches. Below this, it changes to a more compact silty clay loam. Light brown or buff is the more common coloration but in places gray and yellow mottlings prevails, especially in the lower subsoil. The reddish-brown gravelly till is usually found between the depth of 30 and 40 inches but on the level areas there may not be much change in character of material within 50 inches of the surface.

Along the zone of contact there is usually a higher moisture content than in the middle or upper subsoil. A foot or two below this reddish-brown material the till is more or less calcareous. The surface soil is usually acid.

The crop adaptations and tillage requirements of the type are so nearly identical with those of the Miami silt loam that no separate discussion is necessary.

CLYDE SILTY CLAY LOAM.

The soil of this type is a black silty clay loam. The content of organic matter is high, imparting a rather open, friable structure very apparent in well-tilled ground. Below the plow line the proportion of clay is usually higher and the material is more compact. Occasionally it is so dense that it is termed "gumbo," but as a rule it is a very firm black silty clay in which the tendency to break into coarsely cubical granules is well defined. There is not usually so many coarse sand grains or as many small pebbles in this sublayer as in the surface soil.

Below 15 inches the color is much lighter. It is dull brown or drab, often with some brownish iron stains, but the mottling is not usually very pronounced. This material, generally a silty clay,

has a somewhat granular structure, but at a little greater depth it changes to light gray and is very sticky and tenacious if wet. This lower subsoil is not impervious, for as a rule silt particles form a large proportion of the material, and even if no sand is present dried samples show a considerable degree of porosity.

Areas of this type surrounded by the Miami soil usually have a sub-stratum of glacial material. In many instances it may be reached at 40 inches, and the lower part of the 3-foot soil section is a yellow or grayish mottled material with more or less sand. Many of the areas along small streams are underlain by gravel. In such instances the soil contains more sand and scattering pebbles are found on the surface. Practically all of the Clyde soils in Mud Creek Valley have a substratum of loose gravel at from 5 to 10 feet below the surface.

In the type as a whole there is much variation in the amount of organic matter. As a rule it is highest in the soil of the large tracts and lowest in the small, ill-defined areas surrounded by the Miami silt loam, but local differences are often quite pronounced. In innumerable instances the lowest part of an area has a soil containing so much organic matter that it is loose, or almost "chaffy," as the semi-mucky spots are called, while the marginal portions of the area have a firm, silty soil containing no more humus than necessary to insure good physical conditions.

Practically all of the Clyde soils east of White Lick Creek and south of the Cincinnati, Hamilton and Dayton Railroad have but a moderate amount of organic matter. A large proportion of each area is usually silty loam, smooth and friable rather than granular. "Chaffy" conditions never occur in these phases. The subsoils are generally silty clay loams in which aeration and internal drainage are effective to considerable depth, as indicated by the prevalence of brown and yellow coloration.

The areas on the west side of Mud Creek Valley have soils high in proportion of silt. In places the humus content is rather low and the surface appearance of the soil suggests a long period of effective drainage.

In general the organic content is highest in the soils of the northern half of the county, and lowest, or at least more variable, in the southern part.

On Plum Creek, a small tributary of Mill Creek, an exceptionally heavy phase of the Clyde silt loam is found. It is in part, at least, of alluvial origin; the material evidently having been de-

posited by floods from Mill Creek. The surface soil varies from a dark brown silty clay loam to a black, granular clay. The subsoil is a black or drab clay containing some gravel and coarse sand, but usually very sticky and tenacious when saturated. Below 30 inches is somewhat lighter colored and streaked with yellowish iron stains. At about 40 inches below the surface, sandy clay or coarse sandy material of variable structure is found.

The surface soil is well supplied with organic matter—black carbonaceous material—that imparts a loose, crumbly structure, highly favorable to a good condition of tilth. The upper portion of the subsoil is also more or less granular and this structure also prevails in most instances to a depth of 2 feet or more. This insures good aeration to this depth, which in the central part of the area is but little above the usual water table. On the outer margin of this area the surface soil is of lighter texture, having been modified by washings of silt from the adjacent uplands.

This soil has practically the same crop adaptations as the heavier phases of the type elsewhere.

The smaller areas are local depressions in the uplands and the larger ones valleys of present streams or sites of former lakes. In all cases obstructed drainage and conditions arising therefrom have been the chief factors in the development of the type.

The organic matter consists almost entirely of black, carbonaceous material in the form that vegetable debris assumes if its decomposition takes place under water. As an element of fertility it is probably less valuable than organic material in the process of decay in a normal soil, which forms brown humus. But this abundant black humus imparts excellent physical conditions to what would otherwise be heavy clayey soils, and to its presence must be attributed their present high agricultural value.

The Clyde silty clay loam is preeminently the corn soil of this area. The yields are from 50 bushels per acre upward to 80 or 90. The highest average returns are secured from those areas where a water-bearing substratum is found at 3 or 4 feet. If the surface is well drained these phases are but little affected by extremes of precipitation. On the small areas surrounded by the Miami silt loam and including more or less transitional phases between the types, seasonal variations are more noticeable, but the average returns of all crops are exceptionally good.

The occasional spots where the excessive amount of humus in the surface soil gives rise to "chaffy" conditions will improve in

course of time. Washing from the higher ground will tend to correct this trouble. Deep plowing has the same effect. The places where the upper subsoil is a very stiff clay would be benefited by deep fall plowing which by exposure of this clay to the atmosphere gives rise to a finely granular condition and admits of more or less admixture with the coarser organic remains of the surface soil.

Wheat yields are sometimes 30 bushels per acre, but this is much above the average. In seasons of heavy rainfall oats are liable to grow so rank as to lodge badly. In 1913 when but little rain fell in May and June, much better yields were obtained on this type than in 1912, when there was abundant precipitation in the corresponding months.

Clover and timothy make exceptionally heavy yields on this soil. There is usually but little difficulty in securing a stand or maintaining it as long as desired. The soil is not acid, or rarely so, according to the litmus paper test. In some instances the lower subsoil will react to hydrochloric acid, but lime concretions and limestone fragments are numerous in the substratum at less than 5 or 6 feet, where the latter is not exceptionally gravelly. In the latter case the subsoil evidently contains enough lime to meet requirements of all ordinary crops.

Well-drained locations are suitable for alfalfa. Where a very smooth light-colored clay is found at less than 30 inches the average level at which the ground water stands should be ascertained. In such places the drainage may be insufficient for alfalfa. Most of the silty phases that have tile drains or even an open ditch nearby are safe with respect to moisture conditions. Fields that produce good corn and clover and which have water-bearing gravel at about 6 feet are admirably adapted to alfalfa. The soil would be benefited by lime, and inoculation may be necessary.

Commercial fertilizers are not generally used on this soil, practically none are needed. It is probable that no profitable increase in yields could be secured above those obtainable by means of better tillage and the use of legumes. This statement does not apply to the "chaffy" spots where liberal treatment with potassium in some form is so beneficial to corn.

Under continued cultivation there is a noticeable tendency toward reduction of the original organic matter content. Farmers state that some ground that has long been in cultivation now requires more labor to keep it in good tilth. The most practicable

means is turning under of clover. This is practised to a considerable extent on the black soils but in no such measure as to compensate for the steady drains occasioned by the almost continuous cropping to corn.

The present price of this land unimproved except by artificial drainage is generally above \$100.00 per acre. Well improved and desirably located farms consisting chiefly of this type command from \$150.00 to \$200.00 per acre. The rental value is in the neighborhood of \$7.00 or \$8.00 per acre.

CLYDE LOAM.

The soil of the Clyde loam to a depth of about 6 inches varies from a moderately heavy black loam to a sandy loam. There is a rather high percentage of clay present so that the material when wet is slightly sticky and the tendency to form friable clods is very observable in cultivated fields. They crush easily and the fine earth is "crumbly," or granular. This desirable structure is due in large measure to the high content of humus, practically all of which is in the form of finely-divided carbonaceous material.

Between the depths of 6 and 15 inches the subsoil is usually a stiff bluish-drab or black clay loam. It contains some sand and gravel and the property of granulation is not lacking but this part of the subsoil is much more compact than the surface soil. In a few places it is so hard to turn with the plow that farmers call it "gumbo."

The lower subsoil is usually a clay or clay loam but contains a good deal of coarse sand and gravel. A light bluish color indicative of rather poor aeration prevails in some places, but most of this subsoil is a dull brown or some shade of yellow with numerous dark-brown iron stains.

Thirty to 40 inches below the surface sand and gravel form a large proportion of the material, and at a depth of 5 or 6 feet in most places the top of what is evidently a deep water-bearing gravel bed is reached.

This description applies to most of the large area on the lower part of Mud Creek Valley. The areas further up the stream and those joining the Clyde silty clay loam are not so sandy.

Practically all has been reclaimed within the last 30 years, or since the channel of Mud Creek has been deepened. The original timber consisted chiefly of elm, ash, hickory and white oak.

The average yields of corn are high. Seventy-five to 90 bushels

per acre are not uncommonly gathered on well tilled ground. The returns from wheat, clover and timothy are comparable with those of corn. The friable easily-tilled soil and excellent moisture conditions of the subsoil and stratum just below render the type almost drought proof, while the drainage is now efficient.

The present price of land is about \$125 per acre. Farms, with good buildings, consisting wholly or in part of this type command a higher price.

A heavier phase of this loam is found on the low Mill Creek terraces associated with the Fox silt loam. The soil is a loam or silty loam to a depth of 8 or 10 inches. The proportion of sand is not so high as in the Mud Creek soil, but there are usually more pebbles and very small stones on the surface. The organic matter content is sufficiently high to impart a good black color and insure a crumbly structure to the surface soil.

The subsurface layer is a rather heavy clay loam that with increase of depth has considerable sharp, coarse sand and more or less gravel. The color ranges from bluish-drab to various shades of brown or yellow. The drainage is good since the main streams in this section have channels much below the level of this soil and loose sand and gravel form the substratum. It is found at varying depths but in many places is not more than 5 feet below the surface.

All of this phase is very desirable farm land. It may not have quite so high a degree of available fertility as the areas on Mud Creek but the crop yields are nearly as high in normal seasons.

MIAMI LOAM.

The Miami loam is a rather broad type embracing the soils found in the rougher parts of the uplands. The topography varies from local elevations with their usually moderate gradients to more hilly lands along the streams where shallow ravines and bluffy escarpments are very common features. Under such conditions uniformity in the texture and structure of the soils is not to be expected. There is considerable variation in this respect, most apparent in the majority of instances when local differences in surface configuration are compared. The soil and subsoil of the material found on steep slopes is usually coarser textured and more open than that on the crests of ridges or where the land is but slightly rolling. In a broad way, however, the agricultural value of the land in any one section near the larger streams does

not differ greatly from that in another area of corresponding size similarly located. The same statement holds true with regard to those developments of the type found on the structural elevations, or morainic hills, of the upland. Locally there may be considerable difference in character of the soil in a ten-acre field, but in comparing areas of much larger size one with another, the average value is about the same.

The difference with regard to topographic position gives rise to two quite distinct phases although the line between them can not be drawn very closely. The surface soil on the slopes along the drainage lines is usually coarser textured and presents more variable subsoil conditions than the phase developed on the ridges and morainic mounds. The latter have a more silty soil and a heavier subsoil, and are usually less stony, although there are many exceptions to the last statement.

The soil of the slope phase—as that near the streams has been termed—is usually a light brown, or grayish-brown soil in which fine sand and silt are the chief components. It varies texturally from silty loam to a fine sandy loam. Coarser material in the form of pebbles and small stones is usually present but not to such an extent as to interfere with cultivation.

The upper subsoil is generally a silty loam moderately compact but possessing good capillarity. Brown or yellowish-brown tints are the characteristic colors but in the heavier phases of this section there may be some grayish mottling. The lower subsoil is brown or dull reddish-brown loam with more or less coarse sand and small gravel. This lower part of the subsoil as well as the material below is usually glacial debris with the relatively high degree of oxidation of the iron content that characterizes the upper part of the boulder clay. In many places the material is a silty clay with a coarse blocky structure. The color in such instances is a dull chocolate or may be obscurely mottled with very dark reddish-brown iron stains.

In practically all instances both soil and subsoil have good internal drainage and the aeration is relatively free and effective to a depth of several feet. The structure induces good capillarity, and as the substratum of glacial material usually has a high moisture content the soil seldom becomes very dry. It is this property, combined with good drainage, that enables this phase to endure seasonal extremes so well. Crops seldom suffer from excessive rainfall nor are they so soon affected by dry weather as on the Miami silt loam.

Compared with the last-named type the slope phase of the loam includes a larger proportion of glacial material. Limestone fragments are sometimes found within the 3-foot soil section, and calcareous material occurs at slightly greater depths. The soil is not generally very acid, although there are numerous exceptions, usually in spots where the silty character is most pronounced.

This phase includes those lands which owe their surface inequalities chiefly to erosion. With the exception of the bluffs along the larger creeks and the ravines extending back into the uplands practically all of the surface is tillable.

A phase of the Miami loam is found on the isolated mounds, low ridges, and larger areas of rolling to very moderately hilly land that form divides between some of the local drainage systems. In general the topography is milder than that of the slope phase. There are no stony bluffs and very few slopes on which heavy implements cannot be used conveniently.

The soil is not quite so clearly differentiated from the Miami silt loam as is that of the slope phase. It is more silty and the depth to the sandy or gravelly part of the subsoil is usually greater—averaging more than 18 inches. The soil materials are practically the same in each phase—a silty stratum overlying glacial materials. The former has lost more or less of the finer constituent through surface wash with consequent reduction in original thickness and an increase in the relative proportion of the coarser particles. On the crests of the local elevations and on steeper hill-sides the surface soil is a fine textured loam or a fine sandy loam. Where the inclination is less or the slopes very long the soil is a silt loam but usually carries some coarse sand, while gravel and small stones are more or less numerous.

On account of the comparatively open structure of the soil and shallow depth at which the coarse glacial material occurs the entire soil section has good internal drainage and aeration. The iron content has been pretty well oxidized and light brown to reddish brown are the prevailing colors. The chief exceptions in this respect occur on level spots and the lower flanks of ridges where the silty material has much more than the average depth. Such spots are essentially a heavy phase of the Miami silt loam.

The largest area of this phase is found on the morainic divide between Danville and North Salem. There are also areas of less extent in the southern and western parts of the county.

On Eel River for a mile or more above the west county line the

bluffs and steep hillsides rise 100 feet or more above the stream. A number of small branches from the north have cut deep ravines, so that in this locality some very broken land is formed but the individual areas of such ground, however, are generally small. The soil is mostly a stony or gravelly loam of little value except for pasture. Along Eel River the Knobstone shales are exposed and influence the lower slopes to some extent, but elsewhere the soils are glacial material.

The limited areas near Danville are a very rough phase of the Miami loam, as are several small tracts in the extreme northeastern part of the county.

The miles of steep slopes on each side of the valleys of the White Lick creeks, having in most instances an inclination greater than 45 degrees, are essentially this type of soil. They would have been so indicated, but their representation on a map of this scale is impracticable. Where the vertical height exceeds 25 or 30 feet these bluffs have been indicated by hachures.

The very small areas shown in so many places are mounds rising from 10 to 50 feet above the general level of the country near them. In the northern part of the county most of these small elevations have a moderately heavy loam soil that on the lower flanks grades to the Miami silt loam. The areas between Amo and Stilesville are prominent ridges with sandy loam surface soils underlain at a few feet by gravel. Some of these areas are inclined to be droughty.

All of this type is locally called "sugar tree land" by farmers. This name, which is also applied to the lightest and best drained phases of the Miami silt loam, indicates the prevailing timber growth. The few remaining "sugar camps" are generally open groves on ground too rough to be easily farmed.

The high agricultural value is due to the excellent drainage and aeration that practically all of it enjoys. It endures seasonal extremes well. As previously stated, the glacial material, excepting gravel beds, generally maintains a high content of available moisture. In most of this type the upper limit, so to speak, of this soil water supply is generally within two feet of the surface. The texture of the overlying material is usually very favorable to capillarity, and to the easy penetration of roots of growing crops. The elements of fertility are thus continually available without those interruptions due to saturation in soil types where the internal drainage is sluggish, or on the other hand, the texture so coarse that the deep subsoil water is cut off.

It is also probable that the total amounts of the essential mineral elements are higher in the three-foot soil section of the average phase of this type than in the corresponding depth of the level upland soils. In the latter case the leached surface materials have not been removed, or but slightly reduced in original thickness, while on the hilly lands erosion constantly tends to bring the comparatively fresh, unweathered rock debris within the zone occupied by roots of growing plants. This is certainly the case with respect to the lime in the boulder clay and must apply in some measure to other elements. The surface soil, however, is acid but not strongly so except in the heaviest phases.

The low content of organic matter is doubtless the limiting element in production of corn, and to a less marked degree of other crops. The average yields of corn may be placed above forty bushels per acre; wheat does well compared with returns on other types, and oats not so liable to be affected by unfavorable seasonal conditions as on either the Clyde soils or Miami silt loam. Some excellent stands of alfalfa have been established on each phase of this type, while clover is ordinarily secured without much trouble.

FOX SANDY LOAM.

This type comprises the coarse-textured soils on the low terraces of the larger valleys. Most of these second bottoms lie well above the flood limits and the drainage otherwise is good. In most instances the outer margin is a gentle sloop or a slight acclivity rising a few feet above the average level of the more recent alluvial deposits between it and the stream. The surface of the larger areas is nearly level, or has a very moderate gradient from the foot of the adjoining uplands and toward the down stream side. The small areas have the more uneven surfaces and also the greater variation in texture of the soils.

These low terraces consist for the most part of reworked glacial material deposited by the stream when its channel was at a higher level than at present. Along the foot of the uplands, in many instances, the material has been derived largely from adjacent slopes, or laid down by transient floods from the small tributaries.

Throughout most of the larger areas the surface soil is a rather coarse sandy loam with enough interstitial material to cause very friable clods to form if plowed when wet. There is usually but little humus except in local depressions. The surface color is dull gray to brown, due to weathering, but the mineral particles almost

invariably have a coating of iron oxide that gives the fresh soil a pronounced brown color.

The subsoil to a depth of about 30 inches—although there is much variation in this respect—contains much more silt and clay than the surface soil. It is usually a reddish-brown loam or clay loam with more or less sand and gravel and frequently many small stones. The lower subsoil is a gravelly clay that with slight increase of depth generally changes to gravel or sand.

On slight elevations and along the marginal slopes the soil is usually a rather light sandy loam and the subsoil is very gravelly, or frequently a loose brown sand. Such spots are droughty and crops thereon soon show the effect of dry weather.

As the uplands are approached the surface becomes heavier and the subsoil has no gravelly stratum immediately below it. If present, the latter is at a considerable depth. In sags and former semi-marshy spots at the foot of the slopes the soil is frequently a black, silty loam, but such areas are small and not of frequent occurrence. But in many instances there is an exceptional amount of yellow iron oxide at certain depths in the subsoil, suggestive of deposits of bog iron.

With some exceptions there is a sufficient depth of fine textured material to hold enough moisture to meet the requirements of crops, but any prolonged drought is likely to test the endurance of this type. It is not quite so safe in this respect as the Genessee fine sandy loam or most of the uplands types. The water table, as indicated by wells, is from 10 to 15 feet below the surface, but the presence of a gravelly substratum may, and undoubtedly does, in many places, prevent capillary connection between this source of supply and the surface soil.

Some successful stands of alfalfa have been established on this soil. Clover also does well. In both cases it is probable that the roots reach water. The soil is not acid, and on the heavier phases near the hills there is more or less direct deposition of washing from slopes where the calcareous till is exposed.

In normal seasons corn yields from 40 to 60 bushels. There would be marked increase if more frequent changes to clover were made. This type is usually treated as an alluvial soil, but most of it receives no periodic additions of silt from floods. The deficiency in humus is not such a serious matter as in the upland types, but the fertility could be increased by plowing under more vegetable matter.

Several of the areas on White Lick Creek near Avon are terraces much older than those just described. They have greater elevation and most of the material forming them is glacial rather than alluvial. The soils are heavier than those on the low terraces of the same stream. In most instances the surface soil is a brown silty loam with considerable sand and gravel and the subsoil is a yellowish silt loam. The drainage is good and the general agricultural value is similar to that of the Miami loam. The slopes are very similar to the rougher portions of the latter type, but the level surface suggests terrace structure and these areas have been included with the Fox soils.

FOX SILT LOAM.

The soil to a depth of about 6 inches is a moderately dark gray silt loam. It usually contains enough medium and fine sand to impart a decidedly gritty feel to hand sample and materially increases its friability. Some gravel and small stones are usually present, but large boulders are of rare occurrence. The organic matter content is low and in most instances does not affect the color below the plow line. In local depressions the humus may be more abundant and if so the soil to a depth of a foot or more is quite dark and slightly granular. The latter property is almost entirely lacking in the normal phases of the type.

To a depth of about 15 inches the subsoil is a crumbly silt loam or silty clay loam rather compact but containing some coarse sand and well rounded gravel. The lower subsoil is usually a reddish or yellowish-brown clay loam with so much gravel that it is difficult to penetrate with a soil auger below 25 or 30 inches. In places the material is a sticky sandy clay. Where stratified gravel is found at a depth of a few feet the lower part of the 3-foot soil section is usually a reddish-brown clay of pronounced granular structure. But unconsolidated sand and gravel is not found at such shallow depths in many places. The substratum, as the uplands are approached, is glacial material that evidently does not contain a great deal more coarse debris than the till underlying the upland soils, but it is sufficiently open to admit of comparatively free underdrainage, and there is seldom any indication of poor aeration. Farmers state that this land is in condition for tillage after heavy rains much sooner than the Miami soils.

This description is applicable to the large areas on White Lick Creek. The surface is nearly level except for occasional ravines extending back some distance from the bluff margins overlooking the valleys. These slopes are too steep to admit of cultivation, but the soil thereon is a gravelly loam that is by no means droughty or unproductive.

The small areas of this type along the middle course of White Lick Creek have not so great an elevation as the larger ones. This is also true of some terrace soils on Eel River near North Salem that are included with this type. In all such instances the surface is more or less uneven and a relatively larger proportion of the entire area is involved in the marginal slopes. The soil is more sandy than that of the higher terraces and the subsoil is quite variable in texture. The agricultural value of such phases is about the same as that of the Miami loam.

The areas of Fox loam north of North Salem are not more than 15 or 20 feet above the stream levels. Those south of the town lie 50 feet or more above the valleys and the general difference in elevation rapidly increases toward the southeast. None of these areas are very sharply differentiated from the adjoining Miami silt loam. The long easy slopes of the latter merge almost imperceptibly into the level surface of the terraces, and there is hardly greater difference in the general character of the underlying glacial deposits. The Fox soils usually contain the higher percentage of sand, are a little darker colored, and the subsoil is seldom quite so heavy or has the mottling characteristic of the Miami silt loam. The surface material is the silt, or loess, that gives rise to the Miami silt loam and is not essentially different in mineralogical composition or general physical properties.

The suggestions concerning the maintenance of fertility on the Miami silt loam apply almost equally well to these heavy phases of the Fox soils. They are deficient in humus and in some places need drainage to render them less susceptible to excess of rainfall. But as previously stated, most of the type has good underdrainage.

Wheat does well on this type, and the average yields according to farmers is somewhat above that of other upland types. The adaptability to clover, timothy, corn and oats compares closely with the Miami loam, but the level surface renders tillage easier and there are not such local differences in the surface soil.

A phase of the Fox silt loam is the principal soil type on the low, broad second bottoms of Mill Creek. The valley of the east

fork below Pecksburg is more than a mile in breadth and all except the narrow flood plain—seldom exceeding a quarter mile across—consists of level bench lands from 5 to 20 feet above the first bottom. Above Stilesville terraces of greater or less extent occur on each of the branches of Mill Creek. The surface of each is very slightly undulating, or may have a perceptible inclination from the foot of the upland slope toward the stream and also down the valley. The surface drainage is good and is supplemented by the generally coarse structure of the underlying materials.

The latter throughout most of the valley of the east fork is gravel, or very gravelly till. The low, isolated hills in this locality have gravelly centers and on the level land adjoining them similar material is usually found at from 5 to 10 feet. At the head of this valley the gravel beds if present seem to be deeper, for the general structure of the soils is more like that of the upland types. The areas above Pecksburg are separated from Miami silt loam chiefly on account of level topography. On the bench lands north and northwest of Stilesville the substratum is a boulder clay.

In general the soil on these low terraces is somewhat darker colored than that of the high terraces. It contains more sand and usually scattering pebbles and a few stones are present, often in considerable numbers, along the margin near the stream. In places there is enough organic matter to darken the surface, but as a rule the humus content is low. A slightly ashy gray color often prevails and there is no crumbliness to soil in such instances. These ashy phases as well as very light-colored silty soils near the upland slopes need artificial drainage. The subsoil is often a mottled gray and yellow silty clay quite close and heavy to a depth of several feet. Most of the phase has an acid soil and lime fragments are not seen except in deeper exposures of the heavier phase of the till.

GENESEE SANDY LOAM.

In each of the larger valleys there has been some development of coarse-textured soils on the first bottoms. As a rule the individual areas are limited to the immediate vicinity of the channels, or to the debouchure of a tributary valley. In the latter case the soil materials include more silt and clay and also stones than in the former. In all instances there has been considerable assortment of materials so that uniformity in texture and structure are not to be found over any considerable development of the type.

On White Lick Creek, between Brownsburg and Plainfield, most of the alluvium indicated as Genesee sandy loam ranges from a brown loamy sand to moderately heavy sandy loam. In depressions there is enough fine material to such depth that the soil is a silty loam, but heavy phases constitute much of the total area. The subsoil is usually a sand or very open material of some kind. Much of the surface is overflowed each spring but a part of these areas are not inundated except by unusually high water, and in no case are the lands covered for any length of time. The high gradient of the streams and the strip of lower ground that immediately borders it in so many places prevents any prolonged occurrence of a flood stage. This is practically true of all the larger creeks in the county.

South of Plainfield the sandy loam near the Meadow is generally a coarse brown sand with enough interstitial material to give most of it some agricultural value. Farther from the stream, where the line between it and the fine sandy loam has been drawn, the soil is a sandy loam of variable depth and texture. All this part is cultivated but somewhat susceptible to dry weather. Small areas near the foot of the bluffs are generally a loam with brownish sandy clay subsoil of sufficient depth to retain moisture fairly well. Most of the latter lie above all liability of overflow from the main stream, and are not usually injured by water from the tributaries.

Most of this sandy soil is regularly cultivated to corn and the yields are satisfactory. Wheat does not do so well except on the heaviest phases. Clover and blue grass usually show effects of dry weather on the light sandy knolls and other places where the subsoil fails to afford capillary moisture during protracted dry periods.

GENESEE FINE SANDY LOAM.

The surface soil of this type ranges from a light, fine, sandy loam to a silt loam. Silt and fine sand are the chief constituents, with a rather variable proportion of coarser particles. Gravel and small stones occur sparingly in most places, but are never abundant. The color is a pronounced shade of brown. Each soil grain seems to be uniformly coated with brown oxide of iron and there is seldom enough vegetable matter present to materially modify this dull ochreous tint.

No definite line may be drawn between soil and subsoil. The latter consists of the same kind of materials, although at a depth of 6 or 8 inches a little heavier and more compact zone is usually en-

countered which may prevail to a depth of 20 or 30 inches below the surface. The lower subsoil is much coarser textured, consisting in most instances of fine sand that with increase in depth rapidly changes to coarser sand with but little interstitial material. Five or six feet below the surface gravel is usually found.

In general the depth of the soil body, that is, the stratum of material having sufficiently close structure to retain moisture well, may be placed at about 30 inches. It is thinnest and also more sandy as a rule near the stream channel and gradually thickens and is heavier in texture as the foot of the bluffs are approached. In the latter locations, in the widest parts of the valleys the depth to the substratum of coarse sand or gravel may be several feet.

Practically all this superficial stratum consists of reworked material of local origin. It is probable that the silty surface covering of the hills has contributed the greater part. It is a comparatively recent deposit, although general overflows are not now of frequent occurrence, except in the narrower parts of the valleys. In the spring of 1913, however, nearly all of this type was inundated; also in 1875, when exceptional floods covered all the alluvial soils.

Near the channels of the main streams and more especially below the entrance of tributaries into the valleys the surface is often overflowed for a few hours at a time, but with these exceptions injury from high waters is not usually very frequent or extensive. In nearly all of the larger areas the surface elevation above the channel, or of the meadow, where the latter is developed, ranges from 3 or 4 feet to as much as 10 or 15 feet near the outer margin of the valley.

In all of the widest portions of the White Lick valleys this fine sandy loam is the prevailing type. On the Mill Creek branches and also on Eel River the texture of the alluvium is more variable, ranging from a moderately heavy silt loam to a sandy loam, but much of it corresponds fairly well with this type and has been so indicated on the map. On the small branches the type is of course quite variable.

Notwithstanding its deficiency in humus practically all this soil has a high degree of available fertility. This is due chiefly to its physical structure. The soil yields very easily to tillage and with a minimum of labor may be kept in excellent tilth. The subsoil is sufficiently open to admit of deep penetration of water while it also has good capillarity and is seldom lacking in moisture. Much

of this supply doubtless comes from the permanent water table which is seldom more than a few feet below the surface. In some places a thin stratum of coarse sand at 30 or 40 inches may cut off capillary connection between the subsoil and the permanent supply below, but this structure is not of common occurrence except on slight local elevations or near the stream channel.

The average yield of corn on this type may be placed at about forty bushels. On the heavier phases, especially the depressions along the foot of the bluff, a much higher yield is generally secured. This is also true of fields where corn follows clover, but there is less of this legume grown on this bottom land than is desirable for the maintenance of as high a degree of fertility as the type is capable of attaining.

Oats usually do well and excellent yields of wheat are secured, but owing to possible injury by winter or early spring floods the latter grain is not generally sown. The higher portions of this land are suitable for alfalfa and some good stands have been established. While the soil is not acid, liming would probably be advantageous and organic matter in some form ought to be added.

The narrow strips on the small branches are more frequently used for pasture than for cultivated crops. Blue grass usually makes a more continuous growth than on the upland soils, especially where the moisture content is above the average, as is frequently the case at the foot of the stony slope.

GENESEE SILT LOAM.

To a depth of 8 or 10 inches the soil of the Genesee silt loam is a light brown or dark grayish-brown silt loam. It rarely contains much coarse material of any kind except perhaps some scattering pebbles on the surface. The percentage of organic matter is low, but owing to the predominance of silt and very fine sand the soil is friable and but little inclined to become cloddy or compact.

The subsoil is a moderately heavy silt loam to a depth of about 30 inches, where it usually changes to a fine sandy loam that with further increase of depth is a sand or light-textured material of some kind. In the lower part of the subsoil mottled rusty-brown and reddish-brown spots occur, but in the upper subsoil the coloration is uniformly a pronounced brown, indicating the equitable moisture conditions that usually prevail.

This is the dominant type on the first bottoms of Mill Creek and its principal branches. The surface is generally level, with fewer

local inequalities than on the fine sandy loam. The average elevation above the stream channel of the area north of Stilesville is from 5 to 10 feet, so that general overflows are not frequent. The general surface drainage is effective and has been supplemented by open ditches.

On each of the branches of Mill Creek the Genesee silt loam is the prevailing type. Lighter variations occur near the channel and occasionally in the wider parts of the valleys, but practically all phases have a high content of silt and are valuable agricultural lands.

Corn is the principal crop to which this type is devoted. Other crops do well and excellent stands of clover are easily established. As stated in the description of the fine sandy loam, the fertility is due largely to good structure and unfailing moisture supply.

The small areas in West White Lick Valley are silty loams corresponding in the main with the larger developments on Mill Creek. The small areas below Plainfield are rather heavy silt loam with enough organic matter to give the soil a dark color. They owe their differentiation from the adjoining fine sandy loam to depositions of silty material from back waters of high floods. The natural drainage in most instances is poor owing to low position and more or less seepage from the bluffs.

MUCK.

In only a few places are there such accumulations of vegetable debris that true muck has formed. In Section 15, Township 17 N., R. 1 W., several small areas of shallow muck occur. The depth seldom exceeds 12 inches, and there is considerable earthy matter mixed with the vegetable remains. It forms a black, spongy soil, grading to a very black, waxy clay, that extends to a depth of 15 or 20 inches. The lower part of the subsoil in many instances is a rather soft silty clay that contains so much carbonate of lime that it effervesces when tested with hydrochloric acid. Where the muck is not so deep, or is little more than a very light "chaffy" soil, the lower subsoil is a yellow clay without unusual content of lime.

These areas indicated, as well as other small ones not shown on the map, are associated with the Clyde soils and produce nearly as much corn and clover per acre as the latter. In most cases potash has been most profitably used with the former crop.

Occasional small accumulations of muck—owing their origin to

seepage from the hillsides—are found at the foot of the bluffs on the lower course of White Lick Creek. Most of them are mapped with the adjoining soil type on account of small extent and comparative shallowness of mucky material.

MEADOW.

The very recent alluvial deposits of the larger streams and the narrow strips of low land along the small branches have been mapped as Meadow. The character of these soils, their drainage conditions and value agriculturally vary so much that no definite classification is practicable.

On the comparatively level uplands of the western part of the county many of the minor drainage lines have throughout most of their courses flat bottoms varying from a few rods to one hundred yards or more in width. The soil of these little valleys, which in many cases are bounded on each side by a low bank or sharp acclivity of several feet, is usually a brown silty loam that toward the head of the branch merges into the Clyde soils. While subject to frequent overflows the drainage at other times is sufficient to admit of a good growth of blue grass or even permit of cultivation. Occasional patches may be so wet that only coarse wild grasses thrive on them, but these are exceptional.

In the northern part of the county the small branches after leaving the areas of black land have cut rather deep narrow courses without much ground subject to overflow until the valleys of the creeks are reached. There is little of this low land which cannot be referred to either the Clyde or Genesee types. There is not much Meadow on the streams in the southern part of the area.

Along the middle course of White Lick Creek and to a less extent on the west fork of that stream the channel is bordered by a strip of sand ground lying from 5 to 10 feet below the adjoining bottom land. It is generally covered with willows, sycamore, and other water-loving trees and bushes. Below Plainfield the areas indicated as Meadow include many sand and gravel bars, for here the stream is rapidly deepening and widening its channel.

In nearly all instances the actual width of the strips of low land is somewhat exaggerated. Where none are shown on the creeks the tillable ground usually extends well up to the banks of the streams.

SUMMARY.

Hendricks County is located in the central part of Indiana, and has an area of 420 square miles. Most of the surface of the northern and western townships is undulating to very gently rolling. In the central and southern part of the county the relief is stronger but with the exception of low bluffs along White Lick Creek practically all the land is easily tillable. The valley of the above mentioned streams and the tributaries are comparatively narrow and bounded by short, abrupt slopes. This is also true of the lower course of the Eel River, but the valleys of the Mill Creek branches and of Mud Creek are much wider and the adjoining uplands rise in long, gradual slopes.

The average size of farms is about 90 acres. Corn, oats, winter wheat, clover and timothy are the principal crops of grain. From almost every farm more or less live stock is annually marketed. Hogs are the most important of the latter products, but cattle feeding is practiced to an extent that places the county among the leading ones in this vicinity of the State. Dairying is becoming an important business, but truck and fruit growing are of subordinate interest.

Throughout the entire area the principal soil-forming material is a surface layer of silty clay, or loess, ranging from 2 to 3 feet in thickness. It overlies a deep deposit of boulder clay whose physical and mineralogical features exert much influence upon the soils.

Whenever the silty clay stratum has about the average depth and the natural drainage is good the Miami silt loam has been developed. It is characterized by light color of the surface soil and rather heavy subsoil. Wheat, oats and timothy do well on this type, but the acidity and deficiency in humus renders it somewhat less suitable for clover and corn than the Miami loam.

The latter, on account of coarser texture and more rolling surface, has somewhat better internal drainage and is not quite so susceptible to seasonal extremes as the silt loam.

In each type several phases are recognizable, chiefly differences in topography, drainage and depth to the underlying till.

The Clyde soils are the black lands found in all the depressions of the uplands and in valleys wherever the natural drainage was poor. They have a high content of organic matter and since artificially drained are exceedingly productive. Associated with these soils are limited areas of mucky, or as locally termed, "chaffy lands."

The strictly alluvial soils are mostly brown silty or fine sandy loams. They consist of material derived locally from the loess and glacial deposits. Owing to the depth of the present stream channels and to the generally sandy nature of the substratum, the drainage of these soils is good. Practically all are under cultivation and highly esteemed for general farming. The three types recognized have been correlated with the Genesee series.

The limited area of second bottoms have soils very similar to the Genesee sandy loam, but since they lie above overflow they have been termed Fox sandy loam.

The high terraces found on each of the large creeks consist of glacial material and have a silty surface stratum so that the soils are almost identical with the Miami type. Then differentiation is chiefly on account of level surface and physiographic position.